The classical coagulation equation: gelation, self-similarity and oscillations

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In 1916 Smoluchowski derived a mean-field model for mass aggregation in order to develop a mathematical theory for coagulation processes. Since Smoluchowski's groundbreaking work this model and various extensions have been used in a diverse range of applications such as aerosol physics, polymerization, population dynamics, or astrophysics.

Fundamental questions are whether the model exhibits gelation, that is loss of mass in finite time, or whether solutions develop a universal self-similar form for large times. These issues are understood only for some exactly solvable models, while in the general case these problems are basically still open. I will give an overview of the basic properties of these models, explain some of the main challenges in the analysis and report on recent progress. We will see that in contrast to common belief solutions to this model can evolve towards a time-periodic peak solutions.